sPHENIX tracking simulations

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The options

We have so far considered (and simulated at some level):

Reused PHENIX pixels   Silicon strip outer tracker
      OR   **+**   OR
MAPS based (thin!) pixels   TPC outer tracker

The goal of the tracking simulations is to characterize the performance of all of the possible combinations (and eventually down-select)

I will try to outline some of the things we need to move forward with this

sPHENIX silicon tracking simulations

So far the sPHENIX silicon tracking simulations have been done with:

Cylinder cell geometry in G4:
- Make a cylinder, subdivide it into cells
- Each cell:
  - Sensor material
  - Cu layer to represent electronics, support and cooling

Hit finding, clusterizing, tracking, ghost rejection:
- Hough Transform to find tracks
- Kalman Filter to extract track parameters
- Evaluation objects!
- Extensive tuning done for central HIJING events
- Works well

sPHENIX TPC tracking simulations

So far the sPHENIX TPC gas simulations have been done with:

Cylinder cell geometry in G4:
- Make a cylinder of gas, subdivide it radially into 40 cells, and in r-Φ
- Drift each voxel to the readout plane
- Diffuse it transversely
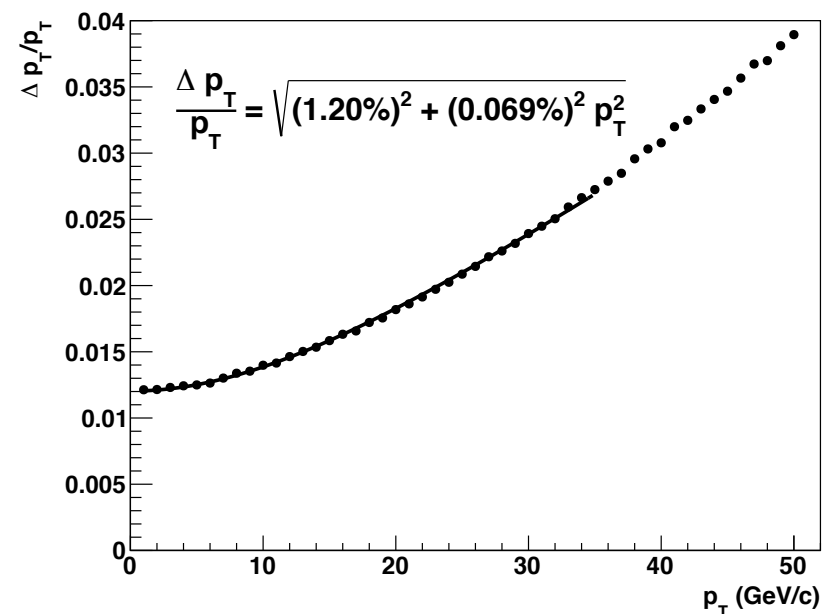- Impose readout parameters to get realistic coverage of pads

Still early days:
- Good estimates of momentum resolution, Upsilon mass resolution
- Lots of work to do to characterize tracking performance in HIJING events

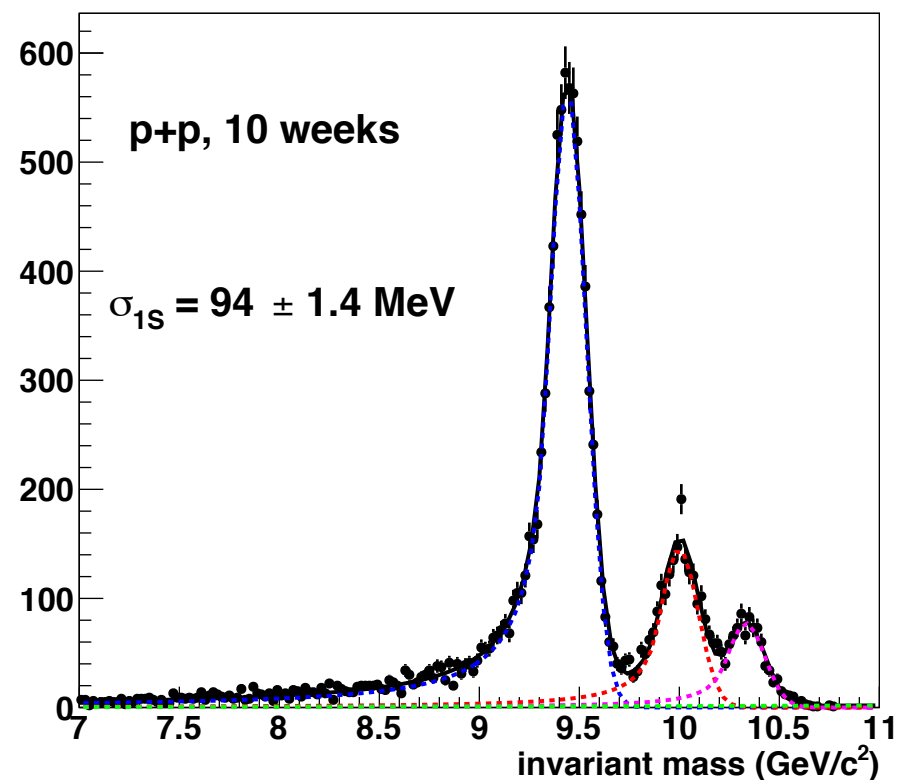# Results to date - silicon tracker configuration

Consider the 5 layer silicon tracker configured for the FPHX chip (what we have in the pCDR) + reused PHENIX pixels - but assuming 100% efficiency

Station	Layer	radius (cm)	pitch (μm)	sensor length (cm)	depth (μm)	total thickness $X_0\%$	area (m^2)
Pixel	1	2.4	50	0.425	200	1.3	0.034
Pixel	2	4.4	50	0.425	200	1.3	0.059
S0a	3	7.5	58	9.6	240	1.0	0.18
S0b	4	8.5	58	9.6	240	1.0	0.18
S1a	5	31.0	58	9.6	240	0.6	1.4
S1b	6	34.0	58	9.6	240	0.6	1.4
S2	7	64.0	60	9.6	320	1.0	6.5

Results to date - silicon tracker - single particle resolution

$$\frac{\Delta\,p_T}{p_T} = \sqrt{(1.20\%)^2 + (0.069\%)^2\,p_T^2}$$

$\Delta\,p_T/p_T$ vs p_T (GeV/c)

Y(1S,2S,3S) $\rightarrow$ e$^+$e$^-$

p+p, 10 weeks

σ_{1S} = 94 ± 1.4 MeV

invariant mass (GeV/c^2)

Y(1S,2S,3S) $\rightarrow$ e$^+$e$^-$

p+p, 10 weeks

σ_{1S} = 94 ± 1.9 MeV

invariant mass (GeV/c^2)
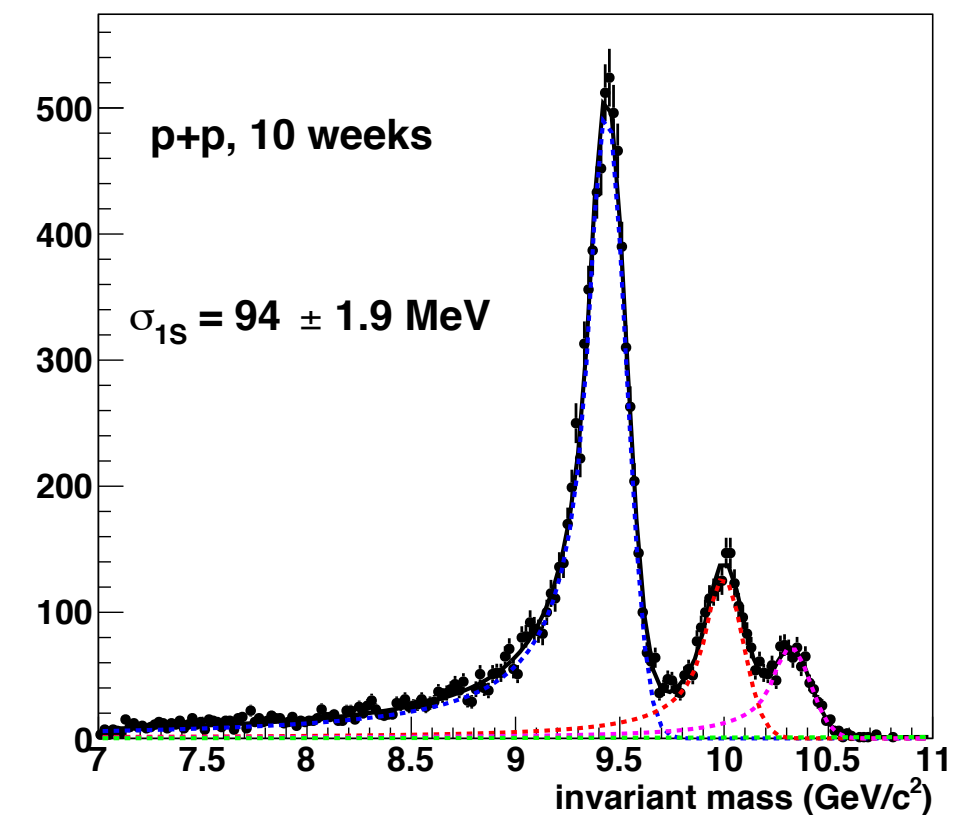
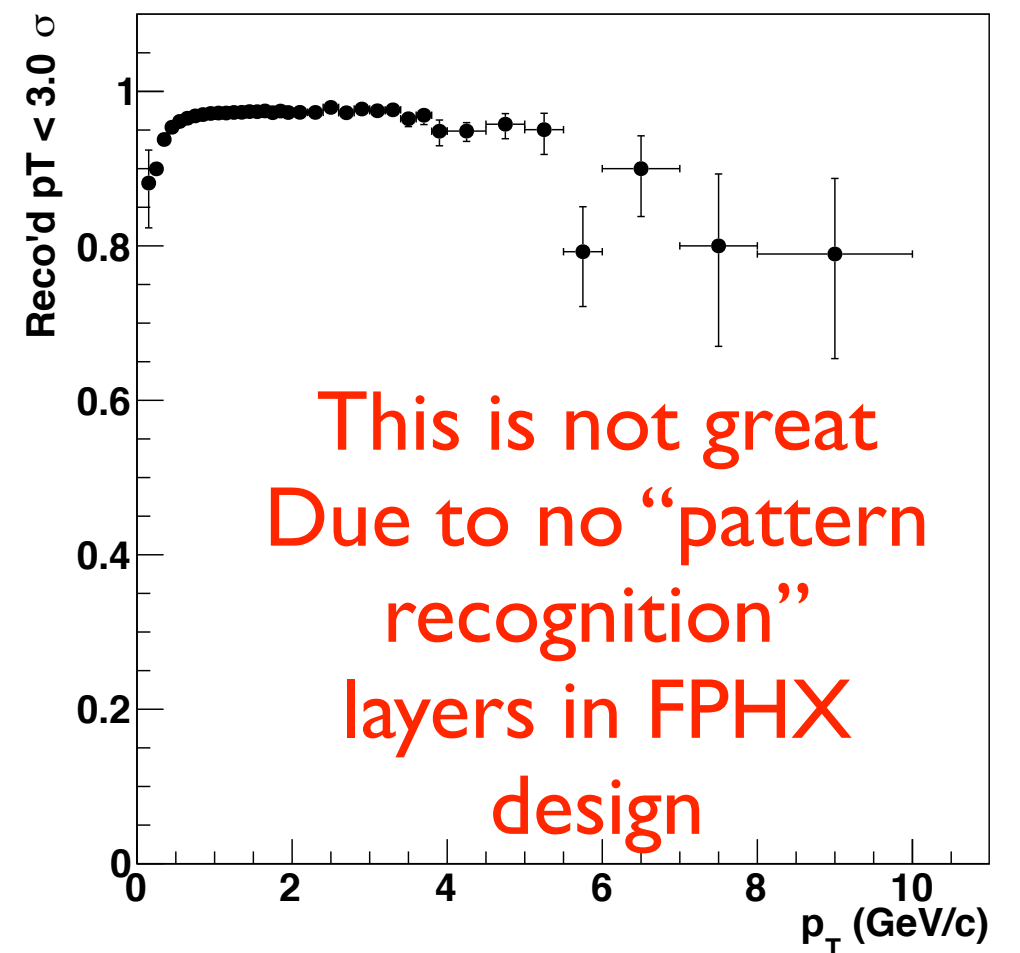# Results to date - TPC - single particle resolution
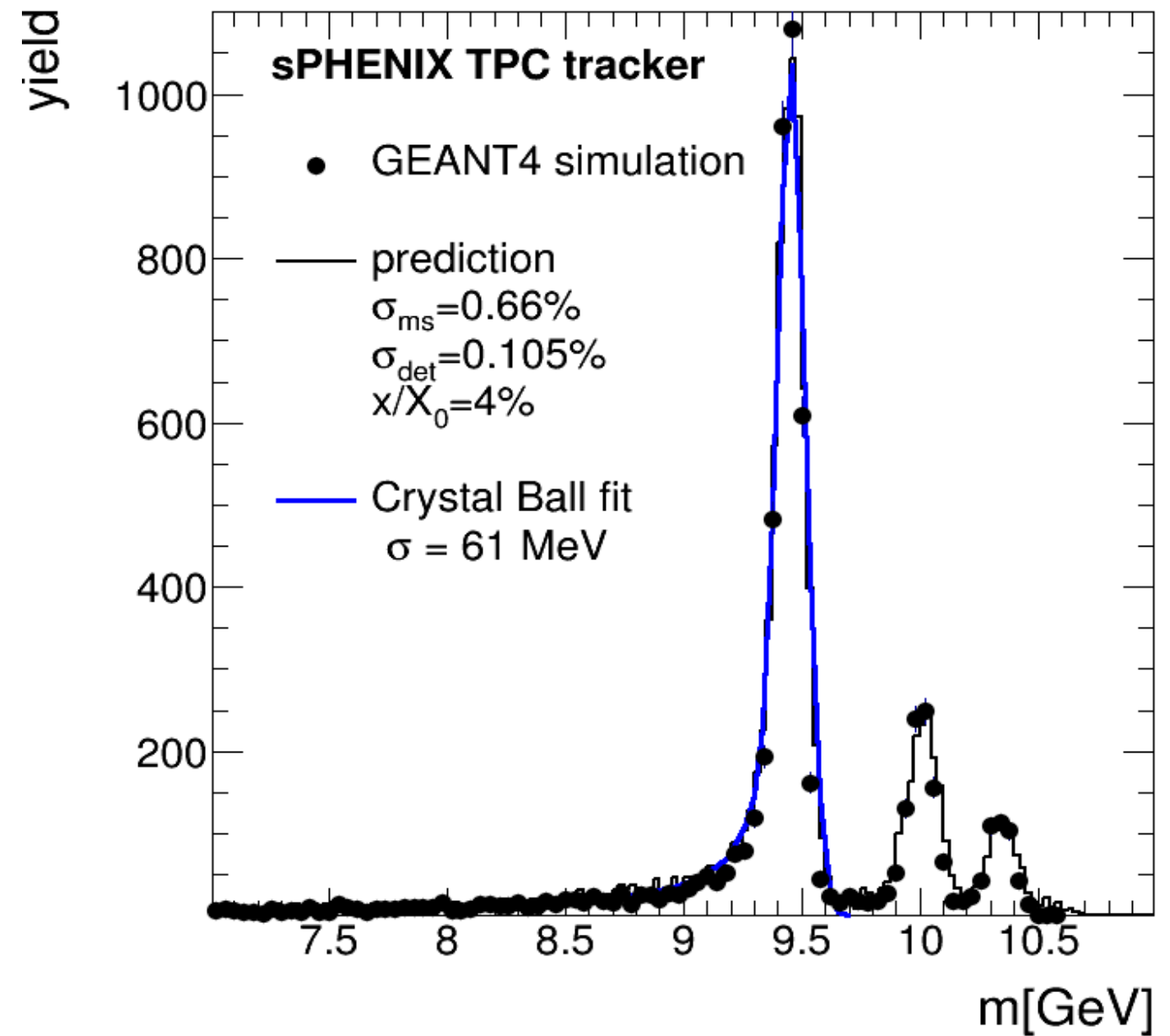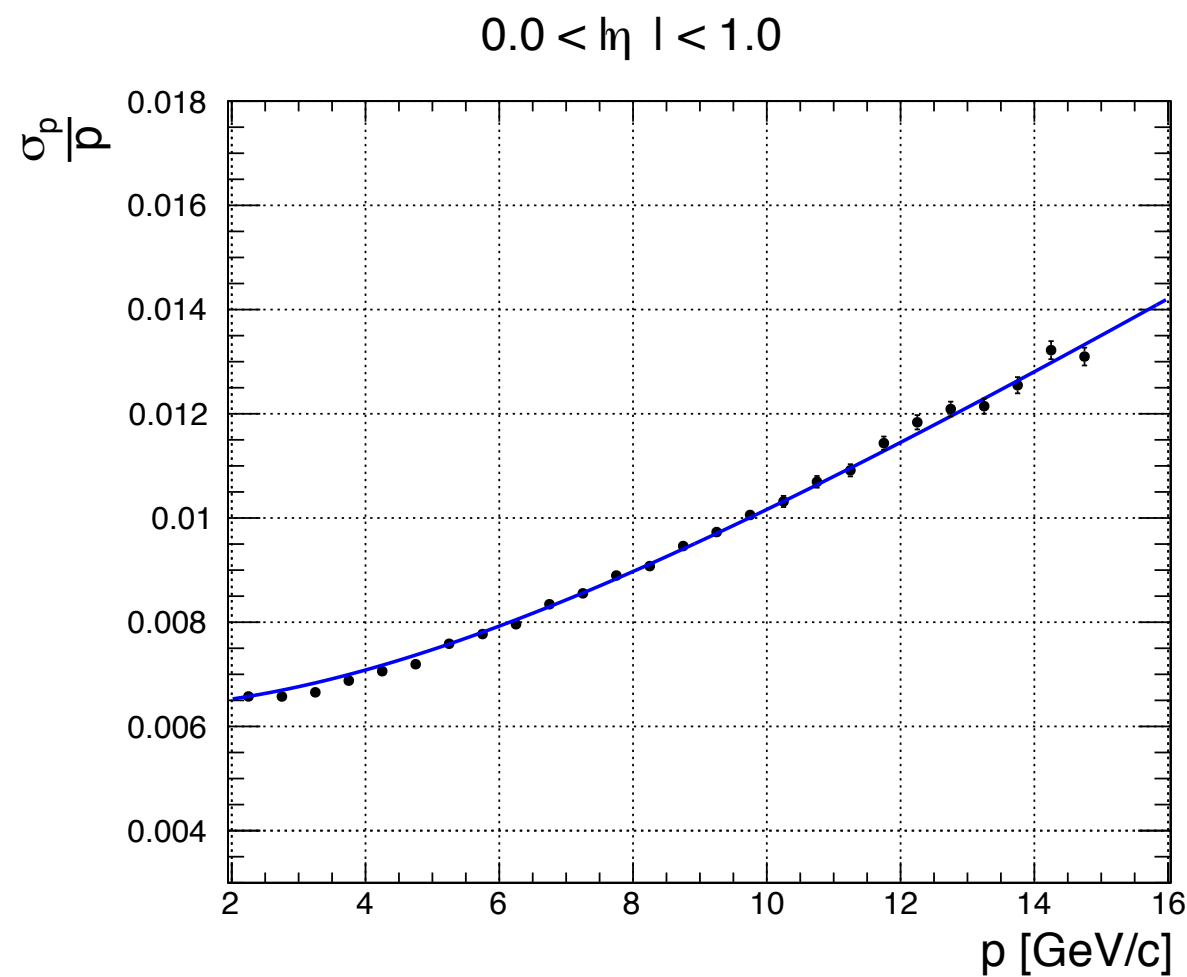
Results to date - silicon tracker - AuAu central

Reconstruction efficiency
all truth tracks reconstructed
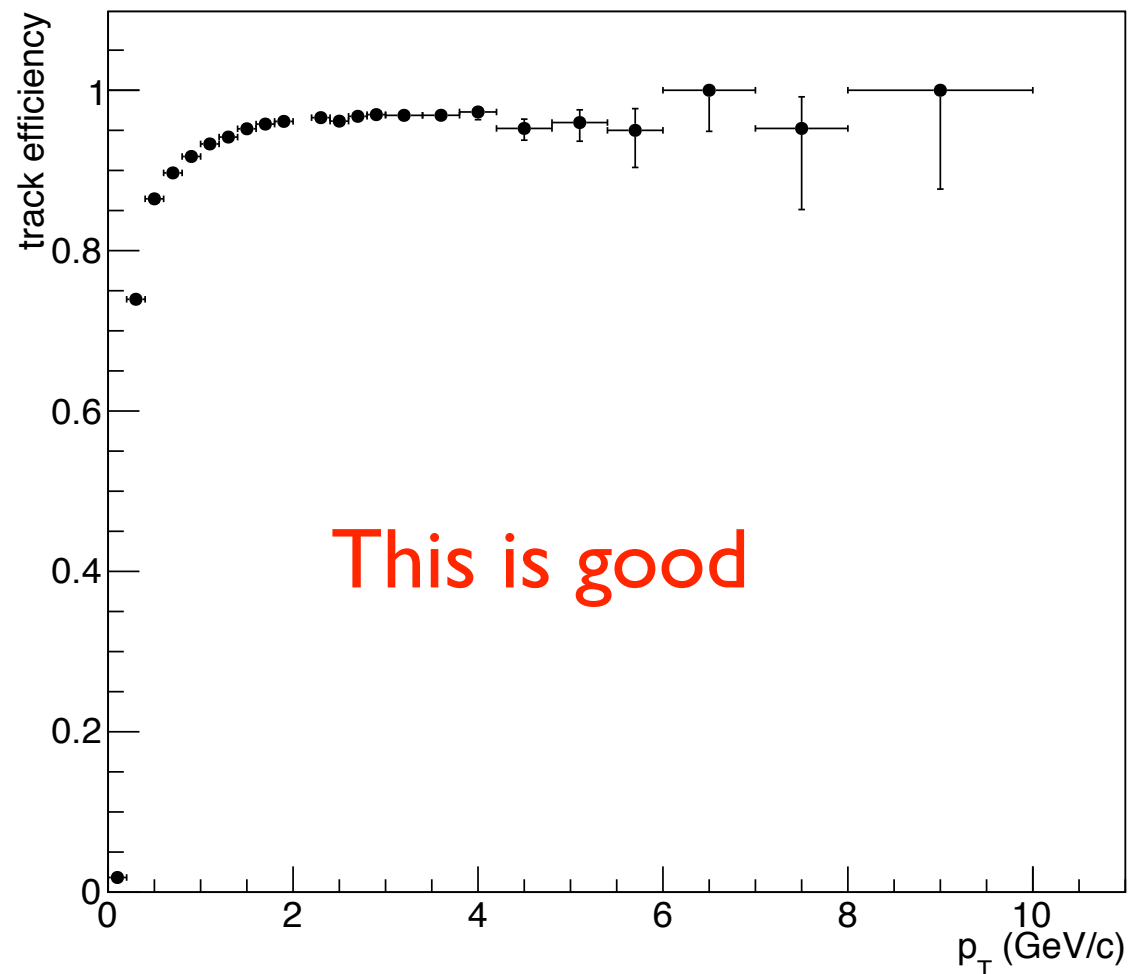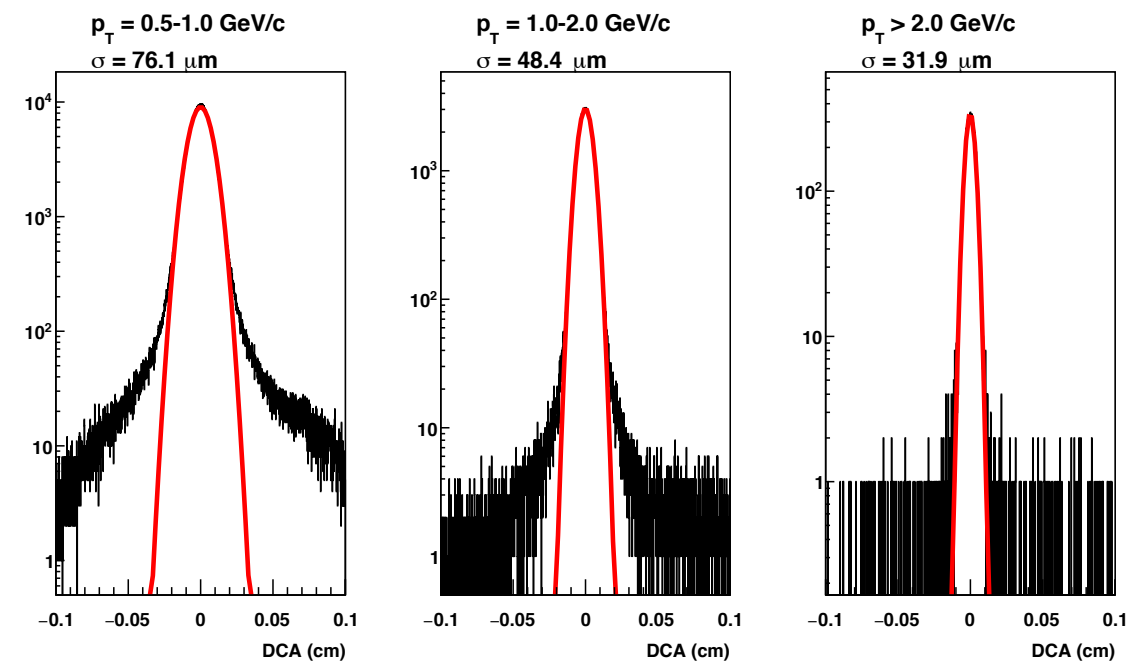**3 σ of truth p_T**

Reconstruction efficiency (3σ in p_T)

This is good

Track purity
all reconstructed tracks within
3 σ of truth p_T

This is not great
Due to no "pattern recognition"
layers in FPHX design

Results to date - silicon tracker - AuAu central

Reconstruction efficiency
all truth tracks reconstructed
$3\,\sigma$ of truth p_T
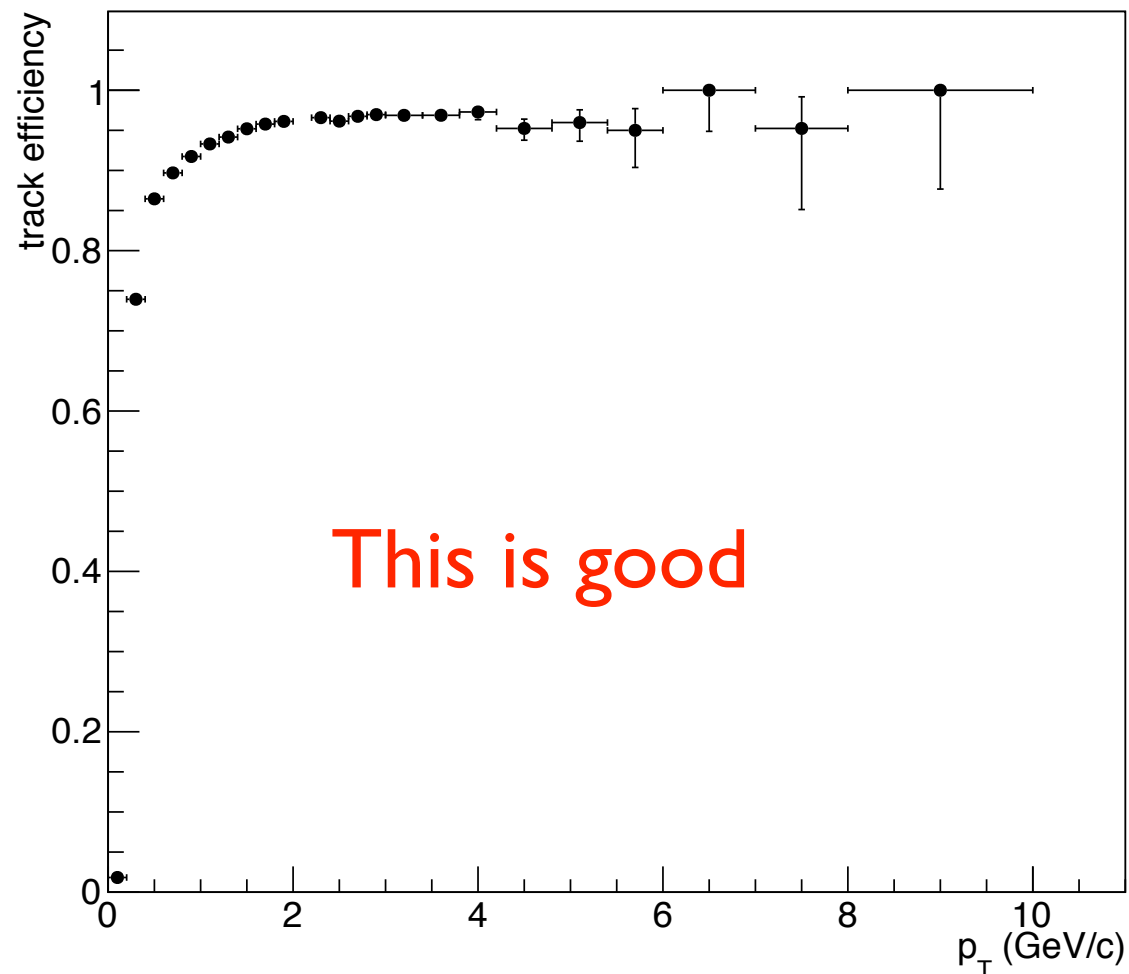
Track purity
all reconstructed tracks within
$3\,\sigma$ of truth p_T

This is good

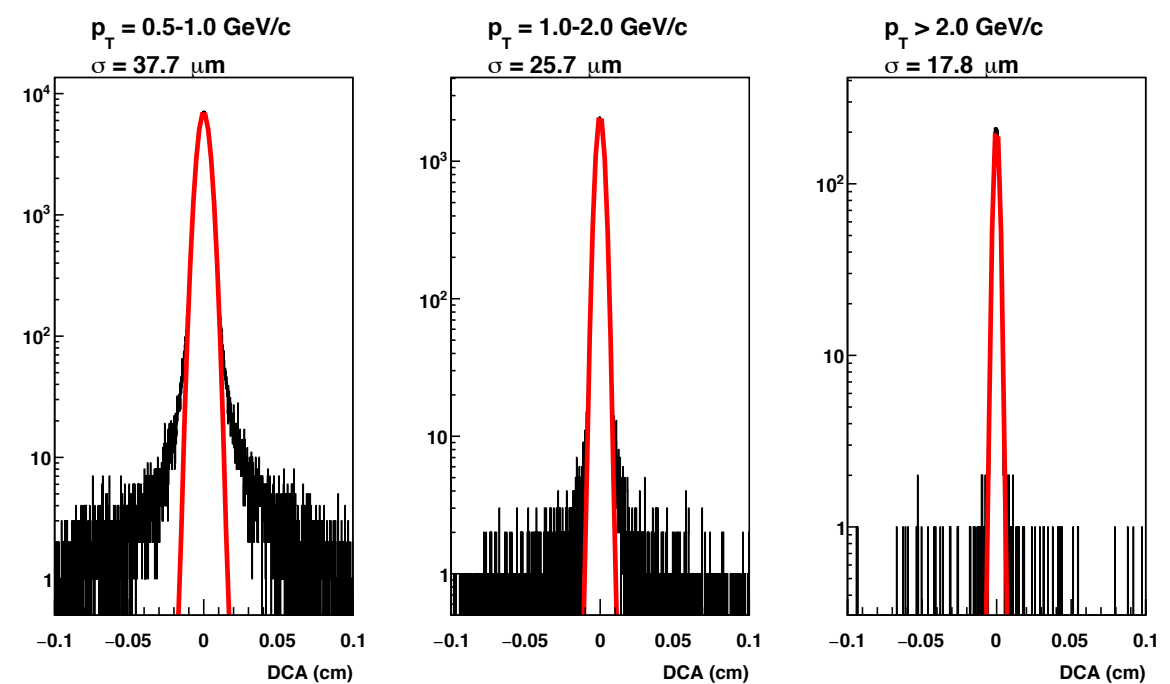ITS inner pixels
instead
This is good
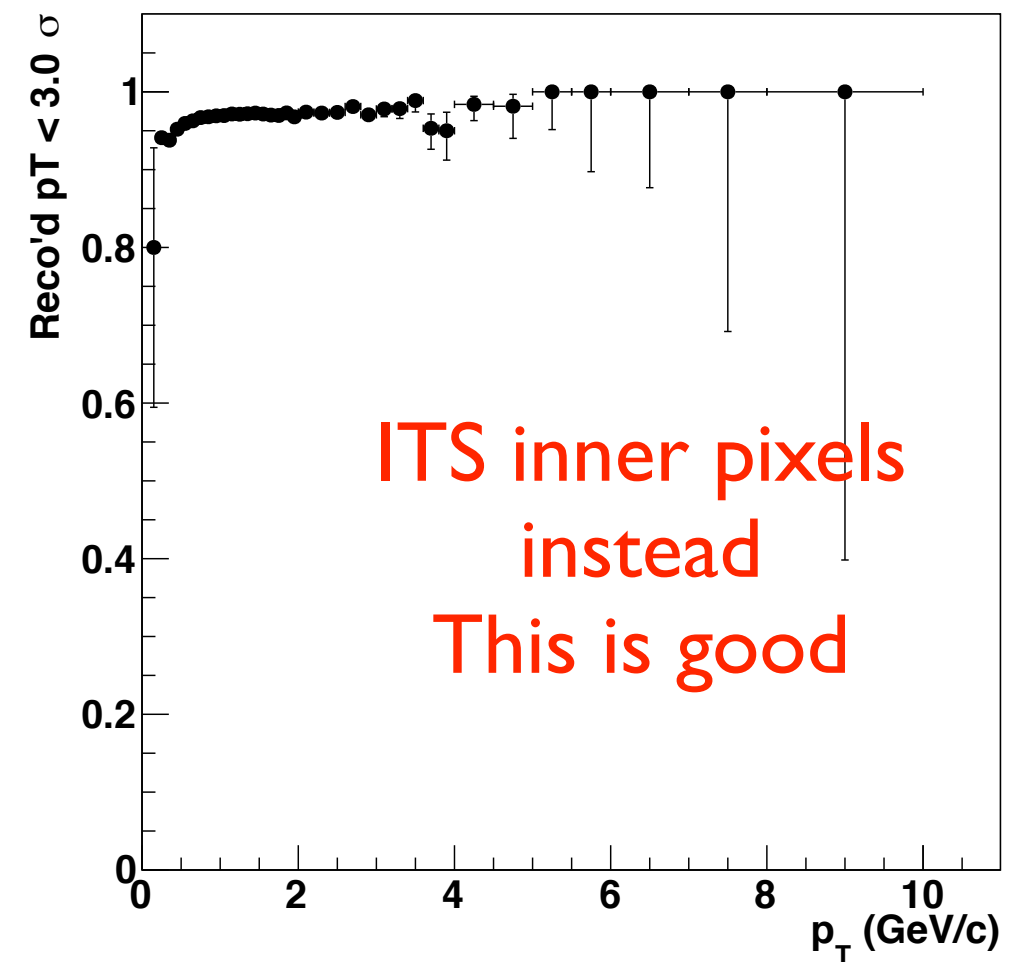
Results to date - silicon tracker - AuAu central

silicon strip + reuse pixels

silicon strip + 3 layer MAPS

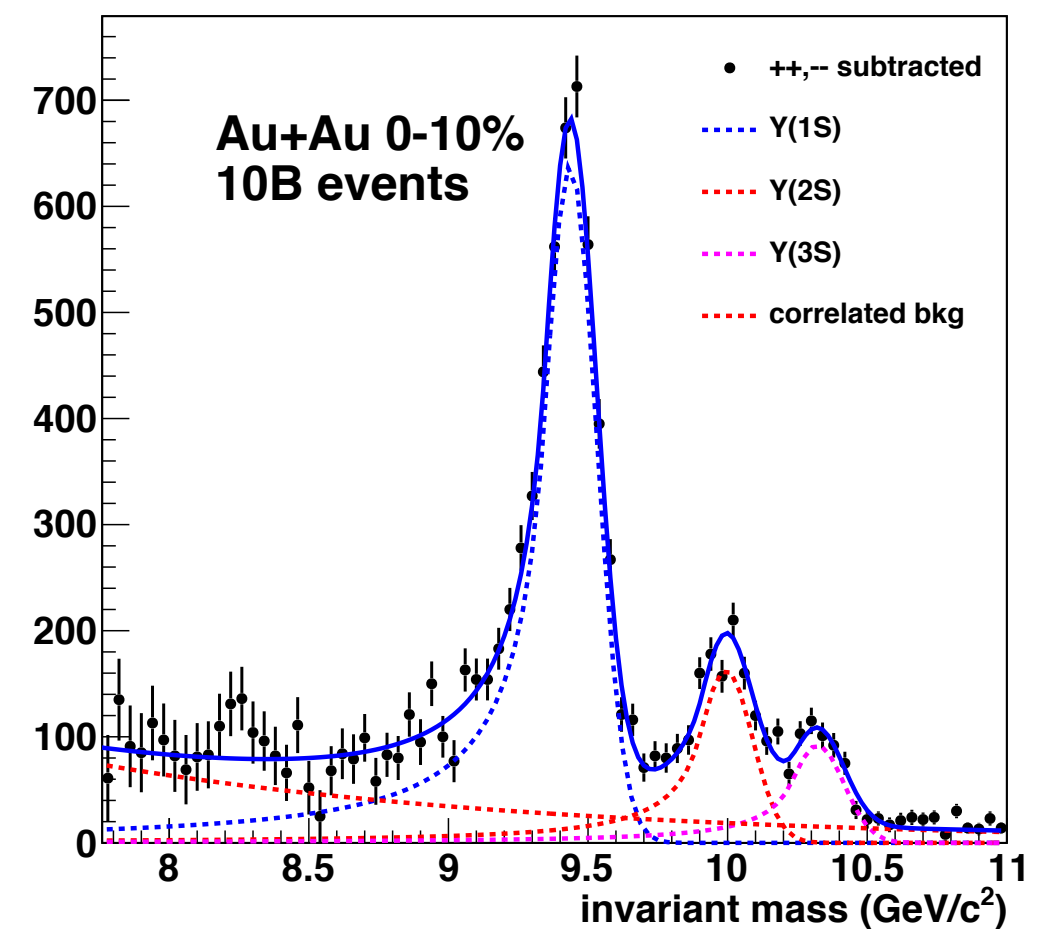# Results to date - silicon tracker - AuAu central

Υ(1S,2S,3S)

Total

Backgrounds:

D Υ,B $\bar{B}$,D $\bar{D}$

D+h,B+h,h+h

1 RHIC AuAu run
100 B MB events
$e^+ e^-$ decays
$-1 < \eta < 1$
π rejection 90
centrality 0-10%
N_{coll} scaled

invariant mass (GeV/c^2)

Υ(1S,2S,3S)

• ++,-- subtracted
Υ(1S)
Υ(2S)
Υ(3S)
correlated bkg

Au+Au 0-10%
10B events

invariant mass (GeV/c^2)
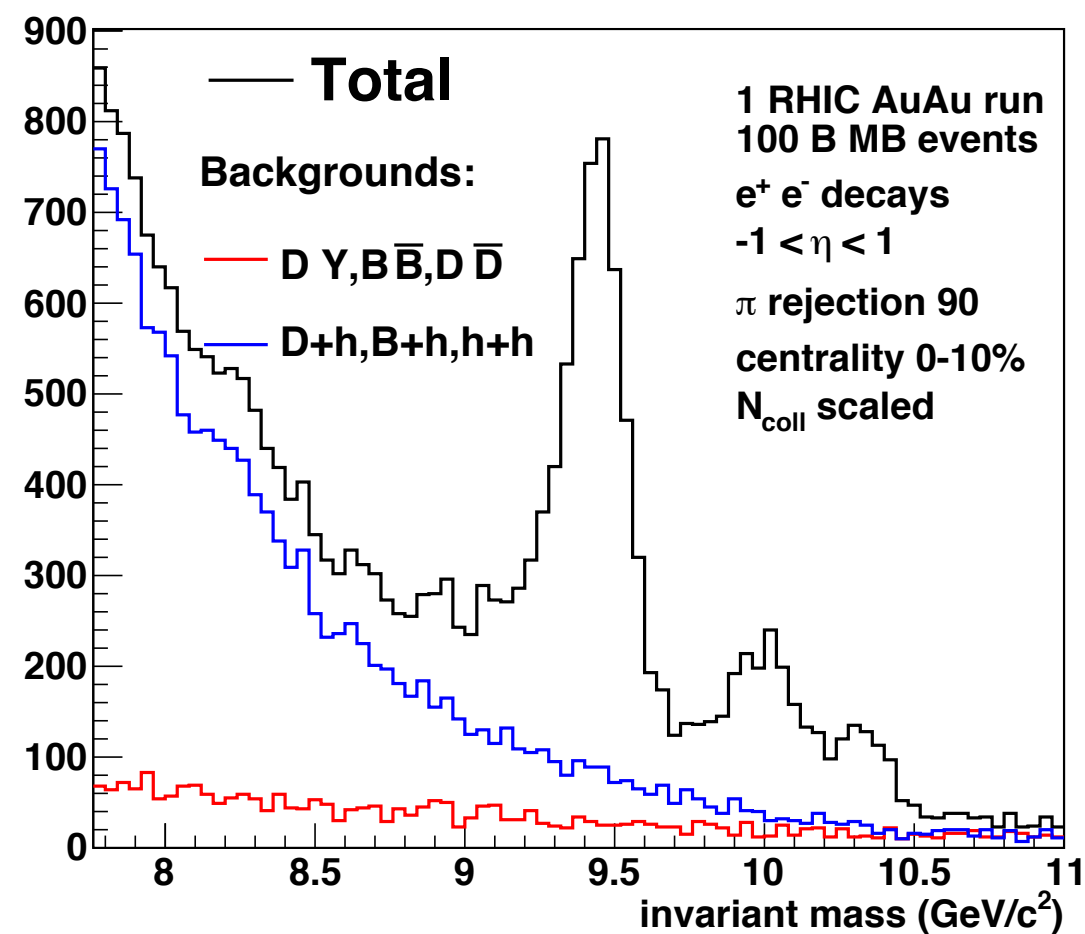
Starting to move on - silicon I

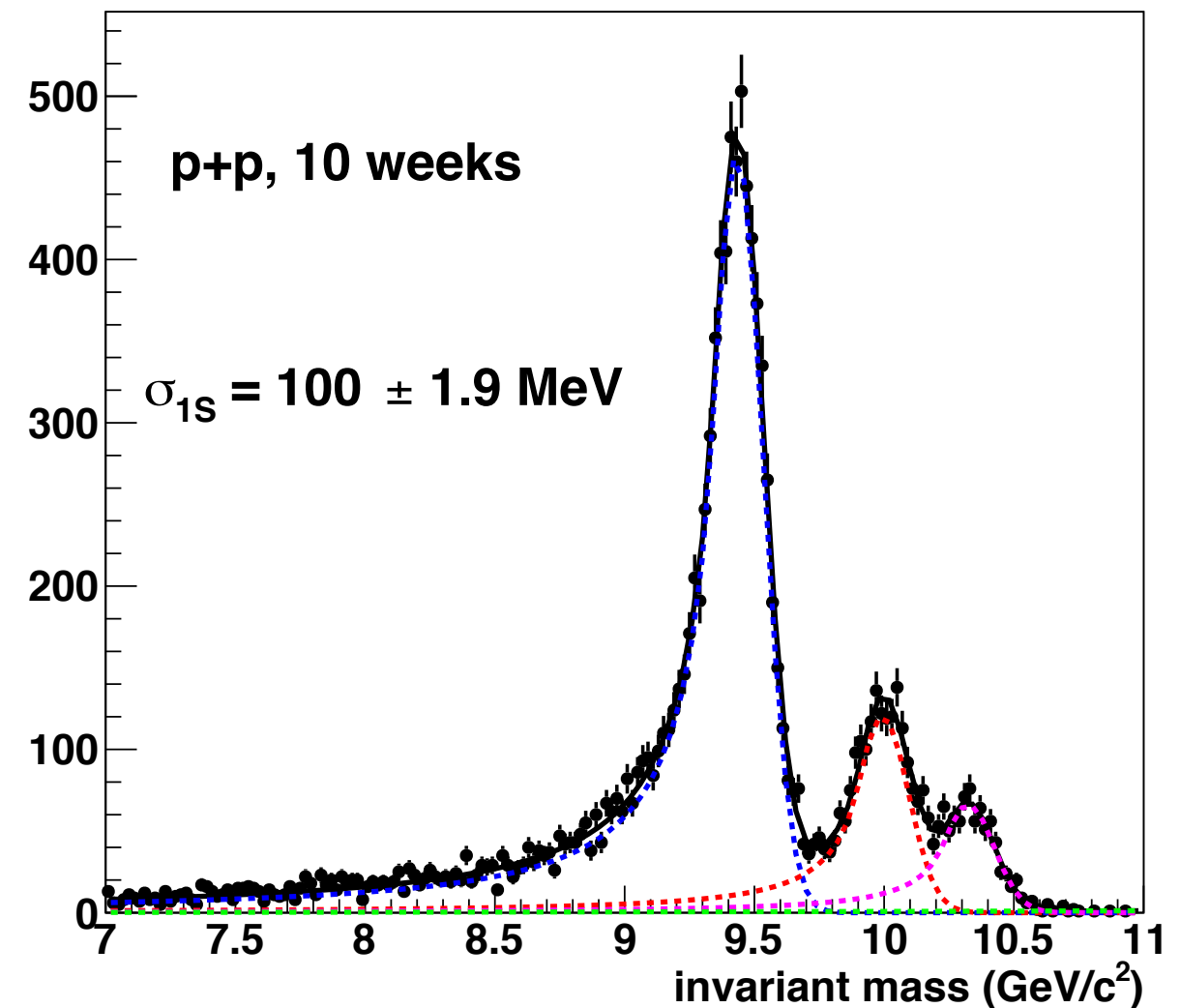Do the dead pixels in the reuse option cause problems for the Upsilon measurement?

Make layer 1 92.5% live
Make pixel layer 2 72.5% live

Require hits in only 6 of the 7 layers

Some loss of resolution, but could likely recover it with tracker setup

Not so bad!

$Y(1S,2S,3S) \rightarrow e^+e^-$

p+p, 10 weeks

$\sigma_{1S} = 100 \pm 1.9$ MeV

invariant mass (GeV/c^2)

Starting to move on - silicon II

Do the dead pixels in the reuse option cause problems for the pattern recognition?

Make layer 1 92.5% live
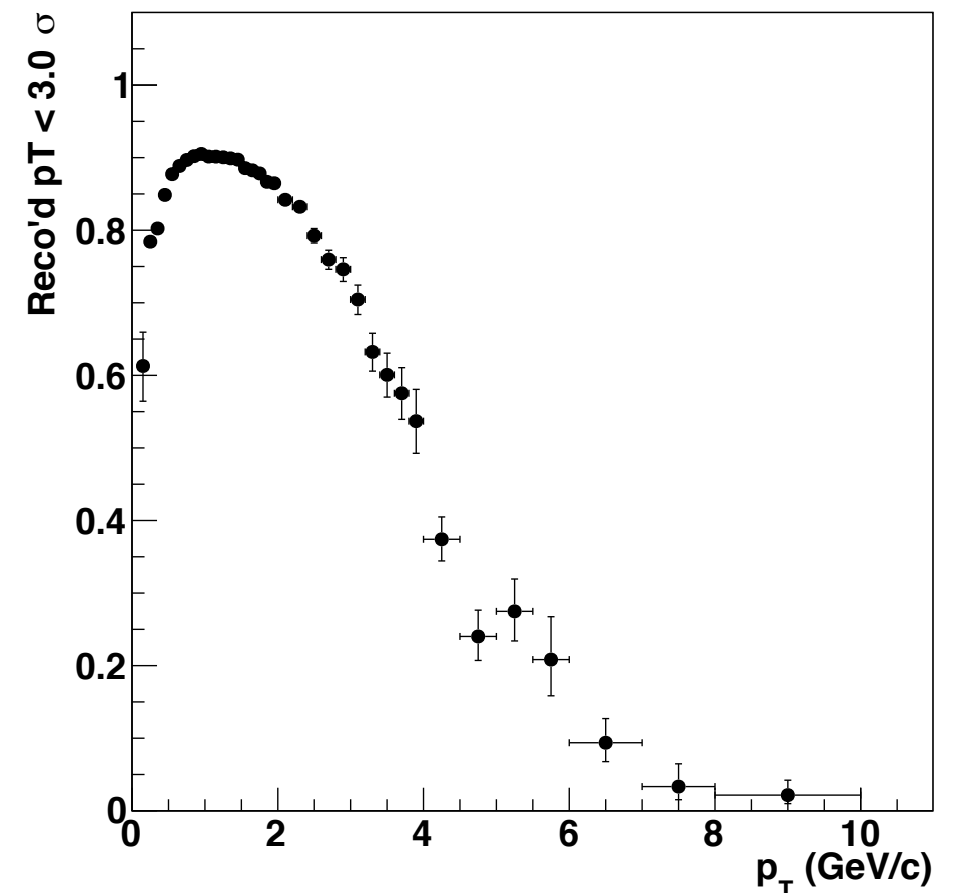Make pixel layer 2 72.5% live

Require hits in only 6 of the 7 layers
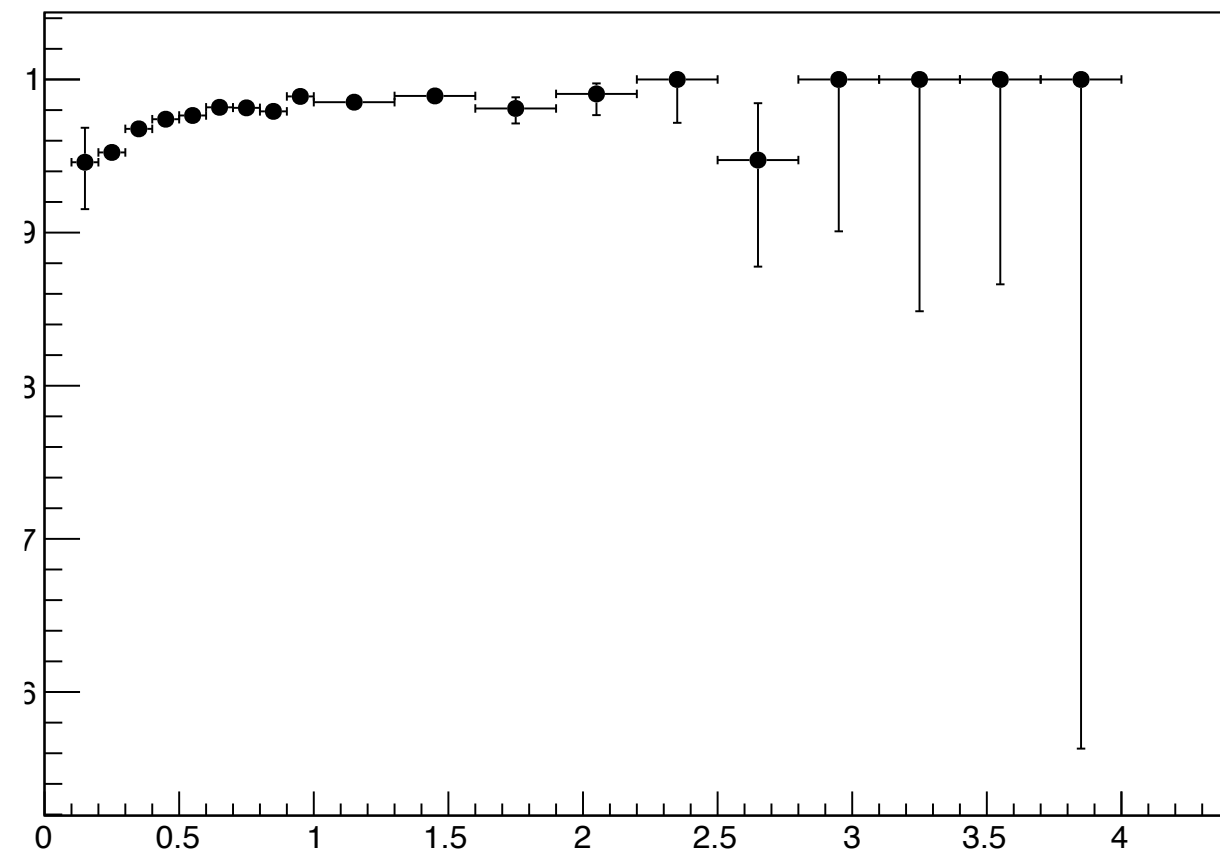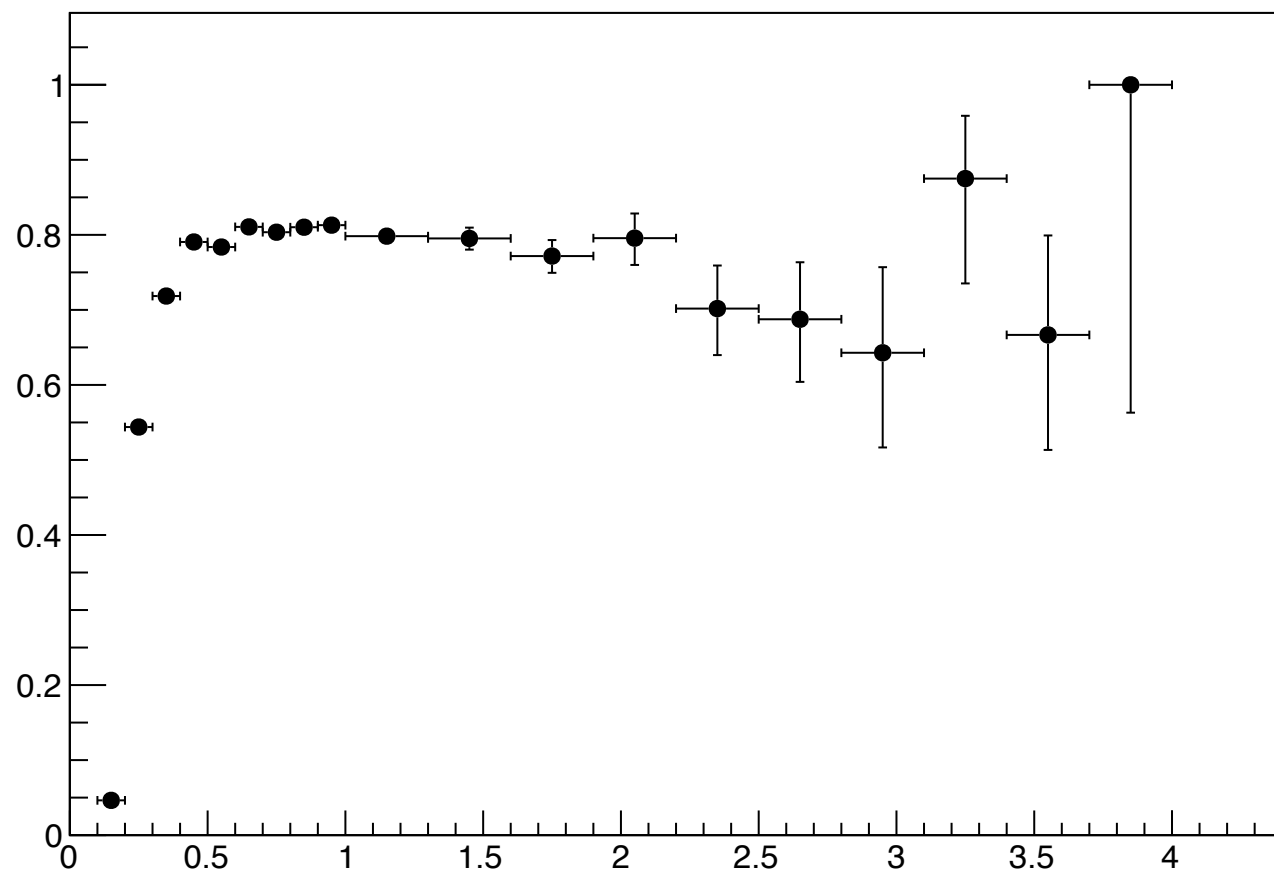
Don't panic - first try!!!

But this needs to be pursued

Track purity
all reconstructed tracks within
3 σ of truth p_T

Starting to move on - TPC pattern recognition

First try!!!!! (i.e. don't panic)

Not many HIJING events due to large memory consumption

Future simulation pushes

Make realistic ladders in G4 for silicon
- Model made for revised MIE design (SVX4 chip)
- Waiting for configuration to settle down for FPHX chip version

Realistic simulation of response of TPC gas (from Alan Dion)
- Ionization part is in pretty good shape now
- Need realistic simulation of analog shaper pulse
- Need realistic simulation of the effects of space charge
- Pattern recognition needs work

Assessment of the "cost" to physics of dead areas in reused pixels

Do we need track matching hardware between TPC and inner pixels?

Do we need to add pattern recognition layer(s) in silicon strip tracker?